REGIONAL PROJECT

FOR THE

ERADICATION OF AMBLYOMMA VARIEGATUM/HEARTWATER

FROM THE CARIBBEAN

PROJECT PROFILE

prepared by the

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C O N T E N T S

AMBLYOMMA VARIEGATUM, DERMATOPHILOSIS, HEARTWATER
IN THE CARIBBEAN

BACKGROUND

In the Caribbean area, ticks are ectoparasites of greatest economic importance. They have a fairly complex life cycle from adult ⟶ egg ⟶ larva ⟶ nymph ⟶ adult. They have free living stages and parasitic stages when they feed on a variety of animal hosts and cause a tremendous amount of harm. They feed by sucking blood leading to anaemia, depressed growth, meat and milk production, even death of their hosts. Some ticks emit toxins in their saliva causing paralysis.

Their biting mouth parts do severe damage to the outer layers of the skin resulting in impairment or loss of hides. Secondary myiasis from Screwworm is common. Ticks transmit viruses, rickettsiae and bacteria, are specific vectors of important animal diseases and have been incriminated in the spread of many others.

Specific Disease Transmission	Non-specific Disease Transmission
*Anaplasmosis	Foot and Mouth Disease
*Piroplasmosis	African Swine Fever
*Cowdriosis	Listeriosis
*Ehrilichiosis	Brucellosis
Theileriosis	Tuberculosis
Rocky Mountain Spotted Fever	Leptospirosis
Nairobi Sheep Disease	Erysipelas
Louping Ill	Necrobacillosis
Russian Spring - Summer Encephalitis	Nocardiosis
Tularemia	Q Fever
	Avium spirochaetosis
	Dermatophilosis

*Present in Caribbean

The Caribbean countries are endemic for the following species of ticks:

- Boophilus microplus - the Tropical Cattle Tick
- Dermacentor nitens - the Tropical Horse Tick
- Rhipicephalus sanguineus - the Brown Dog Tick

Species of Amblyomma Ticks are found with the following distribution at the present time:

Amblyomma variegatum (Tropical bont tick)		Amblyomma cajennense (Silver or Cajenne tick)		Amblyomma maculatum (Gulf Coast tick)
Antigua)		Cuba		Jamaica - reported
Guadeloupe)		Guyana		
Martinique)		Jamaica		Amblyomma americanum
Marie Galante)	Wide	Suriname		(Iguanas)
Nevis)		Trinidad & Tobago		(Lone star tick)
				Dominican Republic
Dominica)		Barbuda)		
La Desirade)		British Virgin Is.)		
Montserrat)		Grenada)	Free	
St. Kitts)	Restricted	St. Vincent)		
St. Lucia)				
St. Maarten/ St. Martin)				
Anguilla)				
Barbados)				
Puerto Rico & Viques)	Reported			
Saba)				
St. Eustatius)				

Amblyomma variegatum - the Tropical Bont Tick - was introduced into Guadeloupe and Antigua from 1830 with the importation of Zebu cattle from Senegal and became established on those two islands. It was reported in Martinique in 1948 through importation of cattle from Guadeloupe. There has been alarming spread of this tick among the islands within the last fifteen years. Examples are St. Lucia 1970, Puerto Rico 1974, St. Kitts 1977-78, St. Maarten 1978-79, Dominica 1983-84.

It was discovered in St. Croix in 1967, viewed with great alarm and sucessfully stamped out by 1970. Similar success is also now being claimed in Puerto Rico and Vieques under their present Tick Eradication Campaign.

Amblyomma species have very long biting mouth parts causing pain and damage to the skin of a great variety of mammals. They are three host ticks, with cattle the preferred hosts. Sheep, goats, horses, deer may be infested while larvae and nymphs may also be found on birds and small mammals. Man and dogs are included in the host range.

BOVINE DERMATOPHILOSIS

This epidermal infection is an exudative dermatitis caused by an aerobic actinomycete, Dermatophilus congolensis, characterized by the formation of multiple sores and horny crusts that adhere firmly to the skin. Direct transmission of the organism is presumed but plants and insects are incriminated as mechanical vectors.

In the Caribbean, acute dermatophilosis was only seen in herds infested with Amblyomma variegatum and questioning of owners and veterinary authorities reveal that bovine dermatophilosis had never been a disease problem on any island until after the introduction of Amblyomma variegatum. Clinical dermatophilosis was very prevalent in Antigua and Nevis and was restricted to those areas of Dominica, St. Kitts and St. Lucia where A. variegatum occurred. Clinical dermatophilosis led to the discovery of infestation with Amblyomma variegatum in Dominica.

For several years, Dermatophilosis has been considered the most severe disease of livestock in Antigua, as it now is where Amblyomma variegatum is well established e.g. Nevis, St. Kitts, St. Lucia. Veterinary authorities have the task of trying to convince their colleagues of this fact because Bovine Dermatophilosis is not a problem where Amblyommma variegatum does not occur.

The disease is abhorrent to livestock owners and butchers and the general public once drawn to their attention. Affected animals respond to prolonged antibiotic therapy but this is expensive and relapses with deaths are common.

HEARTWATER

This is an acute febrile disease of ruminants (cattle, sheep, goats, water buffalo) caused by the rickettsia, Cowdria ruminantium. The rickettsial organisms occur in closely packed colonies in the endothelial cells of blood vessels, especially in the capillaries of the cerebral cortex. The number of granules in any one colony varies from less than ten to several hundreds.

A high fever is followed by development of nervous symptoms such as staggering gait, circling movements, twitching of eyelids and muscle tremors. The animal may collapse in convulsions. Profuse fetid diarrhoea is common.

Heartwater is commonly a mild or subclinical disease in local indigenous stock in endemic areas. In exotic breeds, disease is typically acute, especially when foreign breeds of ruminants are introduced into endemic areas or when the disease is introduced into previously uninfected regions. Mortality rate is usually over 50% in exotic breeds while it may be less than 5% in local indigenous stock.

Heartwater was believed confined to Africa until recently when it was diagnosed in Guadeloupe in 1980 by Perreau et al. A joint United States-French-Dutch research project followed in the Caribbean and the disease was later confirmed in Marie Galante and Antigua in 1984. Fatal heartwater infections

were observed and condirmed at necropsy in goats and cattle on Guadeloupe and in sheep on Antigua.

Diagnosis. A definitive diagnosis of C. ruminantium infection can only be made by demonstration of colonies of the organisms by brain biopsy. Even at necropsy, sampling brain tissue is often considered a tedious exercise.

Treatment. The tetracyclines are effective against C. ruminantium but only if administered very early in the course of the disease.

Immunization. Intravenous injection of blood from a reacting donor animal followed by tetracycline treatment when fever develops has been used with inconsistent results. A grant of $2,000,000.00 has just been awarded for the research development of a vaccine against Heartwater.

Cowdria ruminantium is transmitted by five species of Amblyomma ticks: A. gemma, A. hebraeum, A. lepidum, A. pomposum and A. variegatum. Four other ticks have been shown to be experimental vectors. These include A. maculatum, the Gulf Coast tick, reported from Jamaica, present in Central and South America and the South Eastern States of the USA, Arkansas and Oklahoma. Amblyomma cajennense is classified as a possible vector and is a pest of considerable importance in Central and South America, Cuba, Jamaica and Trinidad and Tobago. A. neumanni present in South America, awaits evaluation as a vector. (See Annex I).

References

PERREAU, P., MOREL, P.C., BARRE, N., DURAND, P. Rev. Elev. Med. Vet. Pays Trop. 33: 21-22, 1980.

BIRNIE, E.F., BURRIDGE, M.J., CAMUN, E. and BARRE, N. Vet. Rec., 1985, 115: 121-123.

ALEXANDER, F.C.M. Summarized review : Heartwater, Dermatophilosis, Amblyomma species in eastern Caribbean, IICA - COINSA II - Brazilia, May 1985.

AFFECTED COUNTRIES - LIVESTOCK POPULATIONS
REGIONAL INTEREST AND RESPONSE

BACKGROUND

The Caribbean archipelago consists of islands in post colonial development. Many are now independent while the French islands are provinces of France. Spanish, French, Dutch and British rule has been the main influence on the population composed of mixed descendants of Africans brought over as slaves, of East Indians as indentured labourers with a sprinkling of Chinese and Middle-East settlers.

The islands rely mainly on agriculture, predominantly sugar cane, bananas, coconuts with coffee, citrus and some spices. Tourism is usually encouraged. Livestock production has always been secondary to the main agricultural crops and is largely in the hands of small farmers for which it is often used as undisclosed assets or bank reserves for special occasions. As P.O. Osuji points out - Caricom Livestock Sector - An overview - annex II, a few medium to large specialised livestock farms are found but the region remains a net importer of animal products. The livestock population and its estimated value of Caribbean member countries of the Inter-American Institute for Cooperation on Agriculture is shown in Table I. Table II shows data concerning other West Indian Islands. This reflects sizeable assets with tremendous potential for improvement in countries being pressured for agricultural diversification with limited importation ability.

The islands are free of many of the major livestock diseases. Rinderpest, Contagious Bovine Pleuropneumonia, Foot and Mouth Disease, Vesicular Stomatitis and many others are absent.

Parasitism is by far the greatest economic burden. Ticks and tick borne diseases constitute the greatest losses and now the greatest challenge.

The Eastern Caribbean Islands of Antigua, Barbados, Dominica, St. Kitts-Nevis, St. Lucia and St. Vincent gave support to the USDA, IICA, PAHO fact finding Heartwater mission in 1982.

The Joint US Dutch French Research Project recently studied seventeen Caribbean territories to determine the distribution of A. variegatum and C. ruminantium in the Caribbean. The indebtedness to the staff of the

Ministries of Agriculture for their assistance was acknowledged.

Following the confirmation of Heartwater, recommendations for action have been initiated through the Commonwealth Veterinary Association and IICA's Animal Health Programme to the CARICOM Secretariat for Regional Ministerial support. The Ministers of Agriculture have endorsed all recommendations and are in full support of the development of national and regional projects to combat this menace.

Antigua has agreed to undertake comparative cost-effective trials with Flumethrin (Bayer) and Amitraz - available commercial acaricides, to determine application strategy for control or eradication.

In St. Kitts, in collaboration with the British Development Division, a Project has begun to control the tick population on the islands. Eleven dipping tanks have been constructed and acaricide provided for the regular use of livestock owners. The improvement of the condition of the animals following treatment has proved self limiting in the absence of adequate legislation as owners are unwilling to use the dip if their animals are not obviously infected with ticks or if they have to share the dip with animals infected with Dermatophilosis. Veterinary researchers from Britain, in their investigation of Dermatophilus congolensis on St. Kitts have discovered several variants of the causative agent.

In Nevis, some dipping facilities were also constructed by the Ministry of Agriculture to assist farmers with tick control.

Amblyomma variegatum was discovered in Dominica during investigation of a clinical case of Dermatophilosis in a restricted area of the country. Systematic insecticide treatment of all livestock units in the area has been undertaken since 1984 and to date there has been no report of spread of the tick outside of the area.

In St. Lucia, an OAS sponsored project has begun with tick control measures in the two main affected areas of the island. Through IICA's Animal Health Programme, a prefeasibility study for Tick Eradication was completed by Dr. Glen Garris, Animal Research Specialist and a socio-economic study in relation to this by Professor Martin Hugh Jones of Louisiana State University, USA. Both documents are with the Ministry of Agriculture.

In September 1985, IICA sponsored a training workshop on Tick Eradicati Measures in Puerto Rico, hosted by USDA and the Commonwealth of Puerto Rico fo Caribbean veterinarians.

Recommendations have flowed from COINSA and RESANTILLAS meetings and fr the 1st CARICOM Veterinary Meeting held in Jamaica in May 1985. Endorsements and recommendations have been received from the Ministers of Agriculture under CARICOM at their recent meetings, in May in Jamaica and in October in Georgetown, Guyana 1985. (See Annex III).

Reference

GARRIS, Glen I. Survey of ticks on livestock in St. Lucia and development of a preliminary proposal for the eradication of Amblyomma variegatum (Fabricius) from the island. - IICA, 18 August - 4 September, 1983.

Table 1. Livestock population and estimated value (US$ million) in countries of the Antilles Zone.

Country	Beef	Dairy	Dual Purpose	Sheep	Goats	Swine	Horses	Mules Donkeys	Layers Broilers	Total
Barbados										
Number	500	8500		16000	10000	20000	1700	300	300000	
Value	0.25	4.25		0.48	0.25	1.00	4.25	0.06	0.45	10.99
Dom. Rep.										
Number	1471967			25565	259758		412145			
Value	735.98			0.51	5.19		4.12			745.80
Grenada										
Number	4000	500	1500	9000	7500	10000	178	400	193700	
Value	2.00	0.25	0.75	0.27	0.12	0.50	0.01	0.10	3.00	9.25
Guyana										
Number	200000	50000	1200	600000	30000	110000	14000	1000	1700000	
Value	100.00		(buffalos)	1.80	0.90	5.50	14.00	0.20	3.00	125.40
Haiti										
Number	586667			105503	842602	700000	221100	192000	2000000	
Value	293.33			3.16	21.06	28.00	82.62		3.00	431.17
Jamaica										
Number	250000	50000		5000	50000	1000000	5000	20000	5300000	
Value	187.50	50.00		0.15	1.25	5.00	1.00	2.00	7.80	264.00
Suriname										
Number	20000	5000	300	2500	3500	15000	1000		1000000	
Value	10.00	2.50	(buffalos)	0.07	0.08	0.75	0.50		1.50	16.06
Trinidad & Tobago										
Number	4000	20000	8000	4000	27000	40000	4000	500	1300000	
Value	3.00	20.00	(buffalos)	0.12	0.67	2.00	8.00	0.10	2.00	35.89

Source: Animal Health Situation in the Antilles Zone, REDISA III, Argentina, August 5-8, 1981 by F.C.M. Alexander.

TABLE II

Animal Population Data - Selected Islands

Country	Horses	Asses	Mules	Cattle	Sheep	Goats
Antigua/ Barbuda	1000	2000	-	6000	9000	7000
Barbados	1000	2000	2000	20000	53000	31000
Dominica	-	-	-	4000	4000	6000
Guadeloupe	1000	1000	-	93000	3000	36000
Martinique	2000	-	-	57000	54000	24000
Montserrat	-	1000	-	9000	3000	4000
Netherland Antilles	-	3000	-	9000	8000	21000
St. Kitts/Nevis/ Anguilla	-	-	-	8000	24000	15000
St. Lucia	1000	1000	1000	11000	14000	10000
	6000	10000	3000	217000	172000	154000

= 300,000 animal units.

Source: Animal Health Plan for the Americas by the year 2000. - FAO Production Yearbook, Vol. 36, 1982.

TABLE III

Country		Imports	US$ Exports	Difference
Barbados	Live Animals	279,000	170,000	109,000
	Meats	18,982,000	303,000	18,679,000
	Dairy Products	7,101,000	30,000	7,070,000
	Animal Fats	230,000	-	230,000
Guadeloupe	Live Animals	800,000	50,000	750,000
	Meat & Meat Products	36,012,000	44,000	35,968,000
	Dairy Products	20,178,000	18,000	20,160,000
	Hides & Skins	4,000	8,000	+4,000
Martinique	Live Animals	2,123,000	60,000	2,063,000
	Meat & Meat Products	40,744,000	4,000	40,740,000
	Dairy Products & Eggs	23,594,000	84,000	23,510,000
	Hides & Skins	-	-	-

Source: Animal Health Plan for the Americas by the year 2000. - FAO Production Yearbook, Vol. 36, 1982.

GENERAL OBJECTIVE

1. To stimulate and improve ruminant livestock production in the Caribbean by eliminating the Tropical Bont tick, Amblyomma variegatum and the disease Heartwater from the Western Hemisphere.

SPECIFIC OBJECTIVES

1. To develop a regional tick eradication programme for the Caribbean and promote national tick eradication strategies.

2. To execute a National Amblyomma variegatum eradication project in each affected island of the Caribbean.

3. To strengthen regional surveillance and quarantine systems in the Caribbean to deal with exotic ticks.

STRATEGY AND ACTIVITIES

SCIENTIFIC KNOWLEDGE

There must be adequate scientific knowledge on the biology, ecology and host relationships of the target tick species; on the epidemiology of the diseases transmitted by the target organisms; and on the techniques necessary to sucessfully eliminate the target organisms. (Powell and Reid, 1982 - Garris 1983)

1. Establish tick identification facilities with training component
   (a) National (b) Regional or reference.

2. Undertake studies governing distribution of tick species, seasonal population studies and livestock hosts.

3. Identify and map distribution and different ecological zones.

4. Establish recommended ACARICIDE application procedures including
   (a) Support for comparative cost effective trials - Flumethrin and Amitraz in Antigua.
   (b) Dipping baths - acaricide - location $\left|\frac{\text{application}}{\text{time}}\right|$ type of facility.
   Spraying operations - acaricide - location $\left|\frac{\text{application}}{\text{time}}\right|$ type of facility.
   Pour on operations - acaricide - location $\left|\frac{\text{application}}{\text{time}}\right|$ type of facility.

5. Establish surveillance teams to monitor effectiveness and resistance to acaricides. Also prevalence and incidence studies of tick bourne diseases, use of preventive and therapeutic control.

6. Implement appropriate research and technology transfer measures.

INFORMATION AND COMMUNICATIONS

There must be strong support from the Livestock Industry.

1. Increase public awareness of the economic importance of ticks, cost effectiveness of eradication, gain support of the livestock industry.

2. Instruct livestock producers in the proper use of acarícides, the recommended application procedures and safety precautions.

3. Publicize tick eradication measures:
   - Notifiability of Amblyomma species
   - Legal regulations
   - Quarantine and movement restrictions

4. Promote participation and livestock industry support.

5. Prepare information and documentation.

6. Project progress reports and dissemination.

LEGAL, POLITICAL SUPPORT AND COMMITMENT

There must be strong support from the legal and political area and a long term commitment of manpower and financial resources.

1. Sign agreements with political directorate for eradication procedures.

2. Obtain long term commitment.

3. Draft and introduce legal enactments in support of eradication procedures.

4. Establish protocol to effect legal compliance.

ANIMAL HEALTH INFRASTRUCTURE

A comprehensive animal health infrastructure must be available.

1. Establish personnel requirements and obtain them.

2. Identify equipment, materials, supplies and procure them.

3. Train personnel in eradication procedures:
   - Quarantine regulations
   - Acaricide applications
   - Surveillance
   - Legal regulations
   - Project promotion propaganda.

4. Establish sanitary defence systems:
   - Notifiability of Amblyomma species
   - Emergency response capability
   - Prevention of reintroduction
   - Surveillance

5. Develop team work - train management skills and promote good morale.

ERADICATION MEASURES FOR AMBLYOMMA VARIEGATUM

(Based on GARRIS - 1983)

These require the following steps:

1. Promote adequate local and political support and obtain programme funds.

2. Conduct detailed FARM to FARM survey - determine host populations and levels of infestation.

3. Place infested herds under quarantine and prevent movement of animals to uninfested areas under appropriate legislation.

4. Treat cattle, goats, sheep, horses, dogs on (7 or) 14 day schedule with appropriate acaricide. All animals must be treated on each occasion. Will require identification system.

   Level and distribution of infestation on island will determine primary focal points and acaricide application/quarantine strategy. Animals maybe moved under certification from a quarantine area, shipped wet or only sent to slaughter.

5. Incorporate all infested herds in eradication programme as soon as possible and involve livestock producers.

6. Risk herds are herds adjacent to infested herds or those moved frequently across uninfested areas. A systematic surveillance programme involving scratch (looking for ticks) of all livestock in risk herds every 14 days to 4 months should be implemented. This surveillance can begin once treatments of infested animals are established.

7. Regimen of treatment programme is to apply a suitable acaricide to each infested animal every 14 days for 18 months. Two months prior to completion of the 18 months programme and for 6 months after, all animals should be thoroughly examined for ticks. If ticks are found on the animals prior to the 18 months, treatment should continue until no ticks are seen on the

animals for at least six consecutive months. If no ticks are found on the animals at the end of 18 months of treatment, the herd can be released from treatment only. These animals should be scratched every 14 days for an additional 6 months and if ticks are found, the 18 month treatment should be resumed.

8. The need for pasture spraying can be considered based on size of pastures, level of infestations, number of livestock available to vacuum pastures and ecological factors.

9. Reinfestation of A. variegatum from surrounding islands should be monitored and prevented by regulations which require animals shipped to be tick free. Routine surveillance should be part of Animal Health Defense System with rapid response capability.

NATIONAL PROJECT ORGANIZATION AND MANAGEMENT

Each national project will have a Director who will be responsible for the following:

1. Supervision of employees under him.
2. Advanced planning to ensure adequate supplies of equipment, replacement parts, acaricide, etc.
3. Prosecution of programme violators.
4. Development of quarterly reports and attendance at Coordinating Committee meetings.
5. Responsibility for day-to-day operations of the eradication project.

Sub-Directors will be necessary in those islands where additional centres are required.

Their duties will be similar to the above but they will report to the Director.

Each crew - whether treatment or surveillance - should have a team leader who would be responsible for the activities of his/her respective team each day.

1. The team leader would be responsible for reporting on the activities of his team to the programme director;
2. He would be responsible for setting up appointments for additional treatments or surveillance activities with the farmers;
3. He would immediately report to the program director program violators;
4. He would be responsible for issuing permits to allow animal movements; and
5. He would be responsible for safety and issuing of the day-to-day supplies needed by his/her respective team.

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Team members would be responsible for their safety in following the regulations given on the proper way to handle acaricides. Team members would also be responsible for the maintenance and care of the equipment issued to them and would report any defects immediately to the respective team leader.

MULTINATIONAL PROGRAMME

Multinational programme will require further direction.

International professional co-directorship and supervision are considered necessary for monitoring management of the national projects and providing support to effect satisfactory progress of each project.

At least three professionals would have responsibility as follows:

A. Antigua, St. Kitts, Nevis
Montserrat, St. Maarten/St. Martin
Saba, St. Eustatius, Anguilla

B. Guadeloupe, La Desirade, Marie Galante

C. Dominica, Martinique, St. Lucia.

They will assist, respectively, national,

A. 6 project directors and 1 sub-director.

B. 1 project director and 6 sub-directors.

C. 3 project directors and 3 sub-directors.

They will form a programme coordinating committee* to report to donor countries through implementing agency or institution.

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*Representatives from USA, UK, France, Holland, CARICOM, UWI, IICA.
Participating directors and sub-directors (20).
30 participants for 20 meetings over period of five (5) years to be held in islands of each area (US$500,000).

JUSTIFICATION

The presence of Heartwater in the Caribbean imperils the ruminant livestock of the hemisphere. It maybe argued that this disease has been present for sometime but the restricted distribution of the vector until recently has limited its impact. This is typical of the mild disease expected of Heartwater in an endemic area. The factors governing transmission of Cowdriosis are not well known but two undesirable facts have been established.

(1) The vector of Cowdriosis in modern times is being spread at an increased rate throughout the islands and should this spread include infected ticks or be complicated by the presence of introduced infected carrier animals, then acute Heartwater must be expected. 50% mortality has been experienced and this could be a very conservative estimate.

(2) Other Amblyomma species exist within the Americas and could be possible vectors. A. maculatum has been confirmed as an experimental vector and Heartwater could be established within the habitat of this specie or that of any other vector once introduced. Initial introduction can produce a disease condition with a high degree of mortality or one requiring expensive prophylactic measures to overcome a potentially diastrous situation.

The devastating effects of Dermatophilosis associated with the tick vector, A. variegatum, call for immediate and sustained action. There have been few diseases which have elicited such great concern and requests for assistance from livestock producers as Dermatophilosis. There have been few diseases which have discouraged livestock production like Dermatophilosis.

Butchers will not purchase cattle for slaughter with Dermatophilosis. Aware persons will not purchase meat if they suspect that they were infected with Dermatophilosis.

Ticks in themselves cause great damage and Amblyomma species with their

long biting mouth parts and larger adult body size do more harm than others. An engorged female will cause 3-5 ml of blood loss. Losses caused by ticks chiefly in relation to Boophilus microplus have been estimated at 50 kg of meat/animal, 0.5 kg of milk per day per cow and US$1.5 per hide - US$20,300,000/year for bovine population of 200,000.

These factors can be considered minimal in relation to Amblyomma species in general and to A. variegatum in particular. Garris arguos that there is a potential increase in cattle numbers in the affected northern areas of St. Lucia of 70%. Without Dermatophilosis and the tick, livestock numbers should increase by an estimated 2,728 cattle which represents a revenue increase of US$1,549,504. This figure alone should provide incentive to undertake an eradication programme.

If this argument holds, with extrapolation to islands such as Antigua, Nevis, Guadeloupe and Martinique where the tick distribution is widespread and Dermatophilosis has been severe for many years, livestock increase could go a long way to reduce the deficits which exist between import/export figures of meat and other products. (Table III).

The programme will also reduce if not eliminate Boophilus microplus, Dermacentor nitens and Rhipicephalus sanguineus from infested areas. The benefits are obvious and would provide additonal reason to complete island-wide campaigns against these species once A. variegatum was eliminated.

Success has attended Amblyomma variegatum eradication projects in St. Croix and Puerto Rico.

PROJECT COSTS

The Puerto Rico Eradication program provided a cost reference for the equipment and personnel required for an eradication campaign. These itemised costs are presented in Table IV and are used as basic unit crew costs. Treatment crew costs are used.

These estimates are based on the costs associated with

1. The number of animals under systematic acaricide treatment;
2. The number of animals under surveillance;
3. The number of surveillance and treatment crews;
4. Equipment (both new and replacement parts); and
5. Operation and maintenance of equipment.

Table VI provides lists of the countries involved and acaricide costs based on the distribution of Amblyomma variegatum. Crews and office centres which will be required are calculated on the above basis as well as on the estimated number of animal units. It is of interest that the calculated cost of eradication done by Glen Garris has already increased by a factor of x3 because of the double focus of infestation on the island.

Office staff and requirements are presented in Table VlI and these figures provide the base for calculating operational, personnel and administrative costs for each island country.

ERADICATION COSTS FOR FIVE (5) YEARS

Country	Administrative Operational Personnel	Acaracide Costs 2nd year	3rd year	4th year	Total
Antigua	1,415,684	291,200	72,800	48,533	1,828,217
Dominica	515,940	20,800	5,200	3,467	589,607
Guadeloupe	6,643,788	2,080,000	520,000	346,667	9,590,455
La Desirade	515,940	52,000	13,000	8,667	589,607
Marie Galante	515,940	104,000	26,000	17,333	663,273
Martinique	4,817,920	1,664,000	416,000	277,333	7,175,253
Montserrat	696,092	104,000	26,000	17,333	843,425
Nevis	1,017,032	208,000	52,000	34,667	1,311,699
St. Kitts	1,017,032	208,000	52,000	34,667	1,311,699
St. Lucia	1,415,684	208,000	52,000	34,667	1,710,351
St. Maarten/ St. Martin	1,031,880	208,000	52,000	34,667	1,326,547
	$19,602,932	5,148,000	1,287,000	1,858,001	26,895,933

Special Equipment where applicable	
Facilities, Spray Dip Machines, Dipping Vats - Antigua, St. Lucia, Guadeloupe, Martinique	200,000
Security - supplies, stores, vehicles	500,000
Training, information, legal services	500,000
Quarantine enforcement and surveillance	500,000
Research and veterinary therapy	500,000
International professional staff	1,000,000
Contingencies and meetings	3,000,000
Grand Total	$33,095,933

Table IV. Itemized costs of personnel and equipment used in individual crews in the Amblyomma variegatum (Fab.) eradication program[1].

Basic crew items	Treatment
	No.
Crew size	3
Leaders	1
Inspectors	2
Personnel Costs	$
Crew Leaders	
Salary	6,780
Fringe benefits[2]	1,042
Bonus	240
Inspectors[3]	
Salary	12,984
Fringe benefits	2,022
Bonus	480
Per diem	
Crew leader	1,560
Equipment costs	
Vehicles (V)	11,000
John Bean Spray er (JB)	5,000
Equipment operation costs	
V depreciation (20% cost)	2,200
JB depreciation (20% cost)	1,040
V maintenance	500
JB maintenace (10% cost)	520
V fuel cost[4]	1,360
JB fuel cost[5]	636

	$
Safety equipment cost	
Rainsuit (6 per individual)	315
Coveralls (3 per man)	167
Boots (1 per man)	90
Gloves (2 pairs per individual)	36
Goggles (1 per individual)	36
Respirator (1 per individual)	75
Cartridges (replacement)	750
Filter pads (replacement)	864
Total	53,288

1. Data supplied by Dr. B. Bokma, Tick Epidemiologist, USDA, APHIS, VS San Juan, Puerto Rico.

2. Fringe benefits - 6.7% of salary for Social Security, 4.25% of salary for Commonwealth State Insurance Fund, $300 (U.S.) per year health benefits.

3. Total for salary, fringe benefits, bonus, and per diem are for 2 inspectors.

4. V fuel costs = Mileage per vehicle per year/miles per litre x $0.34 cost per litre.

5. JB fuel costs = Litre fuel per year x $0.34 cost per litre.

6. Two catridges are issued per man per week and 2 filter pads are issued per man per day of spraying activity.

Table V. Treatment and surveillance crew output for one year as measured by the number of animals treated per day.

Item	Amount or Cost
Gals/treatment	1.9
Spray days/year	240
Animals treated	3,450
Animals scratched	11,683
Treatments/day[1]	150

TABLE VI

AMITRAZ (Tak-tic)

0.025% solution - supplies 760 ml for 100 gallons water.
$20.00/100 gallons ----- treat 50 animal units.

ACARICIDE COSTS - based on use of Amitraz

Widespread A. variegatum Distribution

Country	Crews	Centres	Animal Units	Acaricide Costs
Antigua	4	2	14,000	5,600 x 26 - 145,600
Guadeloupe	28	4	100,000	40,000 x 26 - 1,040,000
Marie Galante	1	1	5,000	2,000 x 26 - 52,000
Martinique	20	3	80,000	32,000 x 26 - 832,000
Nevis	3	1	10,000	4,000 x 26 - 104,000
			209,000	$2,173,600

Restricted A. variegatum Distribution

Dominica	1	1	1,000	400 x 26 - 10,400
La Desirade	1	1	2,500	1,000 x 26 - 26,000
Montserrat	2	1	5,000	2,000 x 26 - 52,000
St. Kitts	3	1	10,000	4,000 x 26 - 104,000
St. Lucia	4	2	10,000	4,000 x 26 - 104,000
St. Maarten	1	1	5,000	2,000 x 26 - 52,000
St. Martin	1	1	5,000	2,000 x 26 - 52,000
			38,500	$390,000
		Total	247,500	$2,563,600

Annual costs based on applications every fourteen (14) days or twenty six (26) times per year at a cost of US$20.00/50 animal units. Applications at this rate should continue for two (2) years. Eradication period is estimated at five (5) years with reduced applications due to the success of the programme.

TABLE VII

Costs per crew units:

1 - $53,288	2 - $106,576	3 - $159,864
4 - $213,152	20 - $1,065,760	28 - $1,492,068

Director - US$20,000 Sub-Directors - US$18,000

Estimated costs:

Main Office Centre (US Dollars)		Sub-centres	
Secretary	7,500		
Receptionist	6,000	Secretary/Receptionist	5,000
Cleaner/Attendant	3,000	Cleaner/Attendant	2,500
Chauffeur/Handyman	4,500	Chauffeur/Handyman	3,500
Guards - 3	9,000	Guards - 3	9,000
	30,000		20,000
Office Equipment			
Files	600		400
Desks	600		500
Chairs	800		600
Xerox	3,500		
Typewriters	1,000		500
Vehicle	12,500		10,000
Miscellaneous	1,000		500
	20,000		12,500
Office Maintenance			
Materials - supplies	4,000		2,000
Telephone	2,000		2,000
Electricity - water	2,000		2,000
Rental	5,000		4,000
Vehicles - petrol, maintenance	5,000		4,000
Miscellaneous	2,000		1,000
	20,000		15,000

TABLE VIII

Country	Year	Crew	Directors	Staff	Office	Maintenance	Total
		4	2		2		
Antigua or	1	213,152	38,000	50,000	32,500	35,000	368,652
St. Lucia	2	149,152	39,000	50,000	-	36,000	274,152
	3[a]	164,152	40,000	52,000	-	37,000	293,152
	4[b]	179,152	41,000	52,000	-	38,000	310,152
	5	89,576	23,000	32,000	-	25,000	169,576
							1,415,684
		1	1		1		
Dominica or	1	53,288	20,000	20,000	12,500	15,000	120,788
La Desirade or	2	37,288	20,500	20,000	-	15,000	92,788
Marie Galante	3	37,288	21,000	21,000	-	16,000	95,288
or St. Maarten	4[c]	52,288	21,500	21,000	-	16,000	110,788
St. Martin	5	37,288	22,000	22,000	-	15,000	96,288
							515,940
		28	4		4		
Guadeloupe	1	1,492,064	74,000	90,000	57,500	65,000	1,778,564
	2	1,044,064	76,000	90,000	-	67,000	1,277,064
	3[d]	1,134,064	78,000	94,000	-	69,000	1,375,064
	4[e]	1,224,064	80,000	94,000	-	71,000	1,469,064
	5	612,032	42,000	52,000	-	38,000	744,032
							6,643,788

a - replace one vehicle;
b - replace one vehicle;
c - replace one vehicle;
d - replace six vehicles;
e - replace six vehicles;

Country	Year	Crew	Directors	Staff	Office	Maintenance	Total
		20	3		3		
Martinique	1	1,065,760	56,000	70,000	45,000	50,000	1,286,760
	2	745,760	57,000	70,000	-	51,000	923,760
	3[f]	805,760	59,000	73,000	-	53,000	990,760
	4[g]	865,760	60,000	73,000	-	54,000	1,052,760
	5	432,880	41,000	52,000	-	38,000	563,880
							4,817,920
		2	1		1		
Montserrat	1	106,576	20,000	20,000	12,500	15,000	174,076
	2	74,576	20,500	20,000		15,000	130,076
	3[h]	89,576	21,000	21,000		16,000	147,576
	4[i]	89,576	21,500	21,000		16,000	148,076
	5	37,288	22,000	22,000		15,000	96,288
							696,092
		3	1		1		
St. Kitts or Nevis	1	159,864	20,000	30,000	20,000	20,000	249,864
	2	111,864	20,500	30,000	-	21,000	183,364
	3[j]	126,864	21,000	32,000	-	22,000	201,864
	4[k]	141,864	21,500	32,000	-	23,000	218,364
	5	89,576	22,000	32,000	-	20,000	163,576
							1,017,032

f - replace four vehicles;
g - replace four vehicles;
h - replace one vehicle;
i - replace one vehicle;
j - replace one vehicle;
k - replace one vehicle;

TABLE IX

YEAR 1

	Administrative Costs	Acaricide Costs	Total Costs
Antigua	368,652	145,600	514,252
Dominica	120,788	104,000	131,188
Guadeloupe	1,778,564	1,040,000	2,818,564
La Desirade	120,788	26,000	146,788
Marie Galante	120,788	52,000	172,788
Martinique	1,286,760	832,000	2,118,760
Montserrat	174,076	52,000	226,076
Nevis	249,864	104,000	353,864
St. Kitts	249,864	104,000	353,864
St. Lucia	368,652	104,000	472,652
St. Maarten	120,788	52,000	172,788
St. Martin	120,788	52,000	172,788

YEAR 2

Antigua	274,152	145,600	419,752
Dominica	92,788	10,400	103,188
Guadeloupe	1,277,064	1,040,000	2,317,064
La Desirade	92,788	26,000	118,788
Marie Galante	92,788	52,000	144,788
Martinique	923,760	832,000	1,755,760
Montserrat	130,076	52,000	182,076
Nevis	183,364	104,000	287,364
St. Kitts	183,364	104,000	287.364
St. Lucia	274,152	104,000	378,152
St. Maarten	92,788	52,000	144,788
St. Martin	92,788	52,000	144,788

YEAR 3

	Administrative Costs	Acaricide Costs	Total Costs
Antigua	293,152	72,800	345,152
Dominica	95,288	5,200	100,488
Guadeloupe	1,375,064	520,000	1,895,064
La Desirade	95,288	13,000	108,288
Marie Galante	95,288	26,000	121,288
Martinique	990,760	416,000	1,046,760
Montserrat	147,576	26,000	173,576
Nevis	201,864	52,000	253,864
St. Kitts	201,864	52,000	253,864
St. Lucia	293,152	52,000	345,152
St. Maarten	95,288	26,000	121,288
St. Martin	95,288	26,000	121,288

YEAR 4

Antigua	310,152	48,533	358,685
Dominica	110,788	3,467	114,255
Guadeloupe	1,469,064	346,667	1,815,731
La Desirade	110,788	8,667	119,455
Marie Galante	110,788	17,333	128,121
Martinique	1,052,760	277,333	1,330,093
Montserrat	148,076	17,333	165,409
Nevis	218,364	34,667	253,031
St. Kitts	218,364	34,667	253,031
St. Lucia	310,152	34,667	344,819
St. Maarten	110,788	17,333	128,121
St. Martin	110,788	17,333	128,121

YEAR 5

	Total US$
Antigua	169,576
Dominica	96,288
Guadeloupe	744,032
La Desirade	96,288
Marie Galante	96,288
Martinique	563,880
Montserrat	96,288
Nevis	163,576
St. Kitts	163,576
St. Lucia	169,576
St. Maarten	96,288
St. Martin	96,288

ANNEX I

HEARTWATER

by

Lonnie J. King*

INTRODUCTION

Heartwater, a serious rickettsial disease of ruminants, was once thought to be found only on the African Continent. However, it has recently been demonstrated by Perreau and his associates to be on the Caribbean island of Guadeloupe (P. Perreau, Alfort, France, 1980). This represents the first diagnosis of heartwater in the Western Hemisphere.

Heartwater, in its acute form, is a septicemic infectious disease caused by the rickettsia Cowdria ruminantium and transmitted by ticks of the genus Amblyomma. The disease is frequently subclinical or mild in established endemic areas but is characterized by pyrexia and nervous symptoms, with high mortality rates outside of this setting. The disease takes its name from a common post-mortem finding of fluid in the pericardial sac.

HISTORY

Cowdria ruminantium was first described in 1925 by Edmund V. Cowdry, from whom the organism derives its name. This rickettsia is an intracytoplasmic, pleomorphic organism that occurs in lymph nodes singularly or in colonies. It has a predilection for vascular, endothelial cells.

The disease was first described in sheep in South Africa in 1830. In 1858 it was mentioned as a specific disease entity. In 1898 it was shown to be transmissible, and in 1900 it was reported to be disseminated by the bont tick, Amblyomma hebraeum. It is a disease that is greatly underdiagnosed today yet is probably one of the most important causes of deaths of domestic ruminants in Africa, especially in imported breeds. Heartwater is a major roadblock to affected countries that want to embark on schemes of livestock improvement.

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GEOGRAPHIC DISTRIBUTION

Heartwater can be found in most African countries south of the Sahara, where Amblyomma ticks occur. The disease is also found in Madagascar and the off-lying islands of Reunion and Mauritius. The first report of the disease in the Western Hemisphere has been confirmed in the French West Indies in Guadeloupe. The presence of heartwater in the Caribbean can probably be attributed to the importation of tick-infested cattle from Africa many years ago, harboring the infectious agent. A heartwater-like disease has been reported from other countries but has never been confirmed by laboratory procedures.

SYNONYMS

Bossiekte, black-gallsickness, gallsickness, mad-gallsickness, Rickettsia ruminantium, blacklung, Malkopsiekte Daji.

SUSCEPTIBLE SPECIES

Cattle, sheep, goats, and Asian buffalo are the domestic ruminants susceptible to Cowdria ruminantium. Some types of African antelopes are also susceptible and in the absence of domestic ruminants can maintain the disease in nature. The blesbok and black wildebeest may be found as asymptomatic carriers. Natural infections with clinical syndromes have been reported in the blacksbuck, springbok, and eland. The European fallow deer has been experimentally infected. Most animals other than ruminants are refractory to infection with this rickettsia. However, laboratory mice and ferrets have supported infections for short periods of time.

CLINICAL SIGNS

The course of the disease varies from subclinical to peracute and encompasses a wide spectrum of signs. The peracute form often has no premonitory signs, and the host unexpectedly collapses and dies. When exotic breeds of livestock are introduced into a heartwater-endemic setting, this is not an uncommon occurrence. The acute form of heartwater probably is the

most common is susceptible hosts. Acute heartwater is characterized by fever, with central nervous system (CNS) and pulmonary symptoms. The fever may be quite high (40-41.6°C) and often diphasic. Prominent nervous signs may include a high-stepping, stiff gait, circling, chewing movements, twiching of the eyelids, protrusion of the tongue, tremors of individual muscles and hyperesthesia. Occasionally, nervous signs can extend to aggression and rage, with unprovoked charging attacks suggestive of rabies. Convulsions with galloping movements, nystagmus, opisthotonos, and muscle tremors portend a fatal episode. The nervous signs are more commonly associated with the disease in cattle. A profuse fetid diarrhea, sometimes hemorrhagic, may also be noted. A moist cough and bronchial rales indicate pulmonary involvement. Pregnant animals may abort during any stage of gestation.

Overt signs of sickness are infrequent in an endemic setting of heartwater disease. The subclinical form of heartwater is common in indigenous breeds where the organism and tick vector are prevalent. Although these animals will have a transient fever, other signs are seldom noticed. The overt cases may be due to the introduction of a carrier host into a previously disease-free area. Others may be clinically expressed due to the movement of infected vectors or possibly will surface as latent infected hosts which undergo stress or other simultaneous infective processes.

The incubation period varies from 1 to 3 weeks after artificial infection by the intravenous route. In natural infections, the average incubation period is 18 days. This is the time from infection to the start of a febrile response in the host. It is thought that the variability in the incubation period may be due to the species of the vector. After the onset of fever, other clinical signs may be observed from 1-9 days later.

HISTOPATHOLOGY

The characteristic histopathological lesion is visceral leucocytosis. Vacuolated reticulum cells are prominent in lymph nodes, particularly mesenteric lymph nodes. Histopathological changes in the central nervous system

include leucostasis, vasculitis, perivascular cell infiltration, perivascular globules, and fibrinous exudation in the choroid plexus and axis-cylinders are swollen.

PATHOLOGY

There are no pathognomonic lesions of heartwater; however, the finding of certain post-mortem changes may justify a tentative diagnosis if characteristic clinical signs were observed. Variability of lesions is due to strain differences of the rickettsia and susceptibility of the host. Peracute infection results in marked edema of the lungs, producing froth in the trachea and bronchi. Although not a consistent finding, hydropericardium, hydrothorax, and ascites are frequently associated with the acute disease. Pulmonary edema and swollen lymph nodes are commonly observed. Petechial and ecchymotic hemorrhages may be found in the heart, lungs, and gastrointestinal tract. Other observations that may be associated with acute heartwater include: hyperemia and petechiae of the abomasal mucous membranes, enteritis with occasional hemorrhages in the large intestine, and an engorged liver with a distended gall baldder. Splenomegaly and congestion of meningeal vessels may be noted, at times, in the acute form of the disease.

CLINICAL PATHOLOGY

The acuteness of the disease is probably a limiting factor to the degree of alterations that are observed, and some conflicting results are seen. Yet there are some hematological changes that appear to be consistent. There is a significant drop in the hemoglobin values and a fall in total serum protein levels during the course of the disease. Initally there is a drop in the lotal leucocyte counts with a decrease in the absolute number of circulating lymphocytes and neutrophils. An eosinopenia is also a common finding in infected animals.

There is a depletion of lymphocytes in the follicles of the spleen and lymph nodes which suggests a depression of lymphoid cellular response; a subsequent reduction in the gamma-globulin level is also a common finding.

Marked disturbances of the acid-base balance have been reported with a resulting metabolic acidosis in the terminal phase of the disease.

PATHOGENESIS

Recent work has demonstrated that Cowdria ruminantium are initially found to exist intracellularly and extracellularly in lymph nodes after phagocytosis. The organism is found in the nodes prior to its appearance in brain endothelial cells. The rickettsiae probably undergo replication in the reticular cells of lymph nodes, are then released into the lymph system, and eventually enter the peripheral circulation. From the blood stream, the organism enters vascular endothelial cells and continues to multiply by binary fission like many other tickborne rickettsiae. Cowdria possess a high degree of target cell specificity.

The invasion of Cowdria damages the endothelium of blood vessels to the extent that there are permeability changes which often result in the transudation of large amounts of fluid in the pericardial, pleural, and peritoneal cavities. The changes in vascular permeability may be mediated by an endotoxin, but characterization of such a product remains nebulous. The invasion of brain endothelial cells results in the central nervous system(CNS) signs.

ELECTRON MICROSCOPY

An electron microscopic study identified structures in the reticuloendothelial (RE) cells of ruminant lymph nodes and in peritoneal macrophages of infected mice as developmental stages of C. ruminantium. These inclusions undergo division and organize to give rise to mature organisms. It is probable that the C. ruminantium is released from the RE cells and then penetrates endothelial cells where further multiplication occurs.

Thus, C. ruminantium has a two-phase development. After infection, initial development is mainly, but not exclusively, confined to RE cells with phagocytic abilities. Here there is eventual formation of mature

organisms free in the cytoplasm of the host cell; the second phase is the development and appearance of membrane-bound colonies of organisms in the cytoplasm of vascular endothelial cells. In newly infected animals some infective organisms probably penetrate vascular endothelial cells at the onset, but it is thought that organisms liberated from RE cells are mainly responsible for the infection of endothelial cells. The cycle in RE cells is completed in 3-4 days post infection.

PRESERVATION OF COWDRIA RUMINANTIUM

The development of a convenient and reliable method for preserving C. ruminantium is essential before the disease can be studied in some parts of the world. A Nigerian isolate was rapidly frozen with or without dimethyl sulphoxide (DMSO) at $-85^{o}C$ and $-196^{o}C$. Experimental animals inoculated with these frozen stabilates were successfully infected. The viability of the organism persisted up to 130 days in the frozen state.

ATTENUATION

Earlier experiments conducted in South Africa attempted to attentuate the rickettsia of heartwater by serial passages in hope that a vaccine would result. A considerable variation in the virulence of the organism was noted through more than 100 generations, but a constant attenuation was not demonstrated. Furthermore, the "attenuated strain" failed to produce any immunity in sheep or cattle.

The white mouse is susceptible to some strain of C. ruminantium. The organism has been passed for more than 20 generations in mice without any evidence of attenuation for mice or sheep.

DIAGNOSIS

There are no satisfactory methods to diagnosis heartwater in a living animal. A provisional diagnosis is usually made on clinical signs and an assessment of herd history. Cowdria ruminantium may be demonstrated in brain

smears of infected animals. The rickettsiae are best seen in smears stained with Giemsa. They are highly pleomorphic, occur singly, or commonly in colonies usually in cytoplasms, and are frequently surrounded by a chromophobic halo. The smaller coccoid forms 0.2 to 0.3 microns in diameter, stain reddish purple, while the larger forms, 0.6 to 1.7 microns in diameter, stain bluish purple.

A brain biopsy technique has been used to diagnose heartwater in the living host. This procedure utilized a Salah needle with a stilette. Tissue is collected with a vacuum, and squash smears are made and stained. This method would seem to be most useful in research studies.

Many cases of heartwater go undiagnosed because of the necessity to open the skull to get brain tissue. Schreuder has described a simple technique for the collection of brain samples for diagnosis of the disease. A sharp spoon or curette and a knife are all that is required. After the head has been removed, a sample of cerebellar cortex is collected with the spoon through the foramen occipitale; thus, the skull is never opened itself. The diagnostic technique appears to be as reliable as the conventional technique of collecting samples from the cerebral cortex.

A small piece of the brain tissue (match head size) is placed on the surface near one end of a microscope slide. A second microscope slide is placed on top of the first and the tissue is squashed between the two. The slides are then moved lengthways along each other while pressure is maintained. The slides are fixed in methanol before staining. Rickettsial organisms seem to be just as prevalent in the cerebellum as in the cerebrum. The important factor is to be certain that capillaries are included in the samples. The glomeruli of the kidney, the choroid plexus, and the hippocampus, are also sites that may be used to make squash smears and look for rickettsias after staining with Giemsa.

To help confirm a diagnosis of heartwater, blood from a suspicious case may be immediately subinoculated into a susceptible host; the recipient animal usually will respond with clinical signs in 6-16 days. The blood should be collected during the febrile stage or shortly thereafter and will

only remain infective for a few hours after it is drawn. The organism cannot be detected microscopically in blood smears. This method is, of course, not applicable as a field test.

Heartwater will continue to go undiagnosed in many instances, until a serological test becomes available. It is difficult to prepare an antigen for this purpose, because the organism will not propagate in tissue cultures.

A capillary flocculation test for diagnosis of heartwater has been developed. Antigen was prepared from the brains of cattle and goats infected with C. ruminantium. Antibodies to heartwater were detected 1-2 weeks after clinical recovery or after treatment; dectectable antibody levels persisted for 1-4 weeks. Results suggested that the test is specific for heartwater and results could be obtained within 24 hours. Unfortunately the test remained positive for only the 1-4 week period of time when serum antibody levels could be detected. This obviously limits its application to recent infections and restricts its use for epidemiological studies. Another problem is the availability of a standardized antigen.

TISSUE CULTURE

Attempts to cultivate C. ruminantium, in vitro, have been unsuccessful. However, kidney tissue taken from infected goats has been used to establish primary cell cultures. These cultures were tested for infectivity by IV inoculation into susceptible goats. Several cultures, up to 13 days old, induced heartwater in recipients. The persistence of C. ruminantium for 13 days is the longest period reported. The organism could not be detected microscopically in cell cultures which may indicate that the organism merely survives but does not multiply. Tick cell monolayers have also been used as tissue culture systems with unknown validity of results.

DIFFERENTIAL DIAGNOSIS

Heartwater, in its various manifestations and forms, must be differentiated from tetanus, piroplasmosis, cerebral babesiosis, rabies, peracute

Nagana, heavy helminth infestation, anthrax, coccidiosis, hypomagnesaemic tetany, plant poisoning, strychnine poisoning, lead poisoning, and organophosphate poisoning.

VECTORS

Heartwater is transmitted by various species of the genus Amblyomma. Currently, A. variegatum, A. hebraeum, A. pomposum, A. lepidum, A. gemma, A. tholloni, and A. sparsum are proven vectors of heartwater. One of the serious threats posed by heartwater results from the continuously changing distribution of the vectors.

Amblyomma ticks are three-host ticks and have the ability to spread quite rapidly, because the immature stages of the tick are indiscriminant feeders and parasitize birds, small mammals, and even reptiles. Transstadial transmission of Cowdria ruminantium by Amblyomma ticks is a consistent finding; transovarial transmission has just been reported, but it is probably a rare occurrence in nature. It has also been demonstrated that a single infected tick can successfully transmit heartwater. The disease can be maintained in wild ungulates not in association with domestic livestock. The rickettsiae infect the endothelium and lumen of the gut in the tick; amplification of the agent may occur within the tick but is not necessary for transmission. The agent has remained viable in a fasting tick for more than 15 months.

A. hebraeum and A. variegatum males after feeding on a host (5-7 days), attract unfed males and females of the same species by producing an assembly pheromone. The production of this chemical ensures that unfed ticks attach on a suitable host and that mating will occur. The presence of the pheromone is essential for the attachment of females and greatly increases the rate of attachment of other males.

Some preliminary work has been done on irradiating male A. hebraeum with ^{60}Cobalt to proudce sterile males and aid in the control of this tick species. Further investigation is needed in order to establish the feasibility of such a control program.

Most heartwater deaths have been reported during the summer months when infestations of adults are heaviest and activity of the Amblyomma ticks is at a peak. There is a long attachment period of the adult stages of their hosts.

The organism in nature is transmitted principally by the female ticks. Males also transmit heartwater but play a minor role in this regard. Their ability to spread the organism is limited by a unique feeding characteristic. The feeding activity of the males is restricted to the period immediately following attachment and then ceases rather quickly. The role of the male is important because their attachment is required as a prerequisite for female attachment.

The Gulf Coast tick, Amblyomma maculatum, has recently been shown to be an efficient, experimental vector of the heartwater agent. This significant finding emphasizes the potential danger of the disease gaining access to the American mainland and maintaining itself in the United States, where this vector is common.

EPIZOOTIOLOGY

Arthropod-borne diseases, such as heartwater, are restricted to certain geographic regions that coincide with their vectors and are referred to as diseases of place. Where heartwater and Amblyomma ticks are well established, there is a high level of immunity in domestic animals, and clinical cases with mortality rates are quite low. This ecological situation is called enzootic stability. When this host-vector relationship is out of balance, epizootics may result. Wild African ruminants that are susceptible to heartwater no doubt play a role as reservoirs for the infection; however, such reservoirs are not essential for maintaining the disease.

Certain breeds of cattle (Zebu) and sheep native to Africa appear to resist heartwater disease due to genetic selection. There are also differences in virulence of heartwater, which are probably due to strain variability. An important factor influencing the incidence of overt disease is the remarkable

age-related innate resistance manifested by young animals who are at risk in heartwater endemic regions. The very young tolerate rickettsial infections and exhibit minimal clinical effects of heartwater. Lambs up to 7 days old and claves up to 4 weeks old are resistant. This resistance is independent of the immune status of the dam.

After infection and recovery the agent has been found to persist in the peripheral blood for up to 60 days. This is a characteristic form of premunition immunity and is critical to the propagation and maintenance of the agent and its transmission by tick vectors. The host then undergoes a period of sterile immunity (6mos. - 5 yrs.) only to be reinfected and produce another temporary state of infectivity; however, a permanent carrier state does not exist.

The seasonal incidence of heartwater peaks during midsummer, which is a reflection of the peak activity of the female Amblyomma ticks. In nature the disease is transmitted principally by female ticks. The transmission process usually occurs within 24 hours after the attachment of the vector.

The fact that infection rates in tick populations in the field are apparently quite low and that immature stages feed on mainly nonsusceptible hosts account for the long interepizootic intervals that can be seen in heartwater. Since the immature ticks may feed on birds, they can be carried over long distances and ifect new hosts out of the endemic locations.

PREVENTION AND CONTROL

Transmission of heartwater may be interrrupted by control of the vector. Acaricidal treatment can reduce the disease incidence to low levels, but eradication in a large area by dipping cattle is not feasible. The future of vector control has been further clouded by the emergence of Amblyomma strains that have developed resistance to the common acaricides (C. Uilenberg, Utrecht, The Netherlands, 1981). There is no heartwater vaccine available, and the only method of immunization is infection and treatment. Infective blood is inoculated intravenously and followed by chemotherapeutic treatment

at the time the animal begins a febrile reaction. Tetracycline is the drug of choice and is given until the fever has subsided. This is not a satisfactory method for large scale use, and it is not without risk. The technique is often limited to highly susceptible purebred calves and cattle.

RESEARCH

There will continue to be major changes in the worldwide incidence and distribution of exotic diseases such as heartwater and of their potential threat of introduction to our mainland.

To properly address the threat of heartwater and develop plans to deal with it, there is a critical need to:

1. Determine its incidence;
2. Acquire knowledge of vector population dynamics;
3. Develop a reliable serological test;
4. Establish a method to cultivate the etiological agent *in vitro*; and
5. Develop an effective vaccine.

THE CARICOM LIVESTOCK SECTOR - AN OVERVIEW

by

P.O. Osuji*

INTRODUCTION

In CARICOM livestock production is a major small farmer activity, in most cases complementing crop enterprises. While a few medium to large specialised livestock farms are found the majority of animal producers are small operators with 5-10 heads of animals. Poultry production, particularly in the MDC's are rather intensive operations with farms of comparable capacities to those found in Europe and North America. In the OECS countries large scale poultry operations have been hampered by difficulties associated with the supply of hatching eggs and/or day-old chicks and feed supply. However intensive poultry production is now on the increase in these countries.

The Caricom Region is a net importer of animal products and in those countries (Jamaica, Trinidad and Tobago and Barbados) where local production of poultry and pork are at or nearing self-sufficiency, most of the inputs, particularly feed, are imported at very high foreign exchange costs. In the OECS countries the recent efforts of the St. Lucia Pig Producers Co-op in attempting to produce good quality pork to replace imports needs to be acknowledged.

Cattle production in the Region is very far from attaining self-sufficiency. This is clearly confirmed by the level of imports of cattle products into the Region in 1980. The FAO Yearbook reported that Caricom spent 99 million US dollars to import milk products and 38 million US dollars on imported beef and veal.

Milk and Beef production in Caricom has been compared with those of Puerto Rico, Israel and Norway. These countries have similar populations though in some cases dis-similar ecosystems to those of countries of Caricom (Table 1). The poor performance of Caricom in both milk and beef production are evident from this table.

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It must however be noted that with respect to beef production both Guyana and Belize are self-sufficient and have export potential. Infact Belize has exported beef to the USA and the French Caribbean territories but not to other Caricom countries.

The Structure of Caricom Animal Agriculture

Animal Production activity in Caricom is found throughout all countries. The sizes of holdings vary from less than 2 ha to more than 200 ha. The largest herds are often found on the government farms or on the larger estates. Cattle and other stock are kept by small farmers in association with bananas, coconuts or other cultivated crops. On the other hand, organised pig and poultry production is on the increase while sheep are kept mainly by small farmers on their holdings. Goats are found on poor pastures and on the scrublands. Rabbits are found as backyard operations.

Breeds and Breeding

Among all species there is a predominance of local types especially among the small farmers.

Cattle

The majority of cattle found are of the dual purpose type, which have a fairly good performance, and constitute about 90% of the population. The best are mainly Guernseys, Jerseys or Holsteins which have been brought in at various times. Santa Gertrudis, Brahmans and their crosses can also be found, especially at the government stations. In Jamaica the existence of 4 distinct local breeds (Jamaica Hope, Jamaica Red, Jamaica Brahman and Jamaica Black) is recognised. Farmers, especially small farmers use either their own bulls, their neighbours' bulls or bulls from the government stations for breeding. Artificial insemination is available in some countries but its efficacy has been questioned in the absence of the necessary support systems.

Pigs

The most common breeds of pigs found are the Saddleback, Large White, La Combe, Large Blacks, Landrace and Durocs. The native pigs can be seen

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running around free or tethered on some farmer's holdings. Farmers usually keep their own boars or use their neighbours' boars, or government boars for stud services. Farmers who own more than one sow usually have some sort of pig housing. While most farmers are in the fattening business, quite a few small farmers are involved in the weaned-pig production business. Weaners being sold to the fattener operators.

Sheep and goats

Other than the few imported breeds (mainly British Saanen and Anglo-Nubian) and their crosses, most of the goats in Caricom are the local types and look like the West African Dwarfs. Most sheep are the white type which seem to have had the same background as the Virgin Island whites. Some Barbados Blackbelly and Wiltshire crosses can be found among all categories of farmers. The importance of the St. Elizabeth wool type in Jamaica and the Blackhead Persian in Tobago are to be noted.

Rabbits

Rabbit production in most of Caricom is a backyard operation even though there are government policies to encourage the expansion of rabbit production.

Production Systems

Cattle. Extensive grazing as in Guyana and Belize utilise indigenous pasture species. Ocassionally, improved species like pangola grass, elephant grass, Tanner, African Star and Coastal Bermuda are among the forage species found in the main production systems. Among the small farmers, roadside grazing, cut and carry, communal grazing and combinations of these with tethering are the main production systems used. Animals are not usually housed, water is taken to the animals wherever they are tethered. No castration or dehorning is practised as a regular routine. In fact small farmers utilise the horns as a management aid in handling the animals and sometimes for tethering. Deworming, though practised sporadically, is not a regular practice of management. Neither is the provision of salt licks. Often the farmers' cattle are kept for both meat and milk. The milk supplied is mainly for home consumption, though farmers with more than one cow sell some milk. The above

does not belie the existence of large dairy farms in Jamaica, Barbados and Trinidad and Tobago. In these farms the Holstein and Jamaica Hope predominate.

Sheep and Goats

Extensive grazing, tethering, cut and carry, communal grazing and the use of crop residues are the main features of sheep production. Goats, when kept, are often on the scrublands as most small farmers recognize the incompatibility of goats with the major food crops grown by small farmers.

Usually and probably because of praedial larceny, sheep and goats are brought in at night. Thus small sheds are provided by farmers in their backyards for housing and feeding the sheep and goats at night. Castration is not a common management feature, nor is dehorning. Small farmers know the value of worming their sheep and goats but due to the unavailability, cost, and lack of expertise, farmers have not wormed their animals routinely. Attempts are made to rear lambs or kids on artificial milk or cows's milk.

Poultry

A large number of local creole birds are reared around the backyard where they scavenge for their food. Some small farmers who grow vegetables in their backyards either have small fenced areas for these birds or small barbed-wire chicken coops for their birds. When a coop is provided, kitchen refuse or cracked corn is fed to birds, and occasionally commercial feeds.

In Jamaica, Trinidad and Tobago, Barbados and to limited extents in Guyana and Belize commercial poultry production has advanced to varying levels of self-sufficiency. In the OECS, however, commercial poultry production is on the increase and the deep litter system of housing is used. Small farmers seldom market chickens but occasionally sell them alive.

Pigs

There are two distinct systems of pig production. The local pigs are either allowed to scavenge or are tethered in the farmer's backyard, when improved breeds are kept by small farmers usually some form of housing is provided, often with a concrete floor. Among small farmers the Lehmann system

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of feeding is used. Farm and kitchen residues, mainly succulents, are fed to the pigs with the use of coconut meal and/or wheat middlings and/or some fish-meal as the protein supplement.

Over and above the small farmer systems described, commercial pig production is important in the MDC's and is on the increase in the OECS. However, the scarcity and high cost of feed seem to mitigate against the finished operation except on the few farms where pig production is a major activity.

A major feature of animal production in Caricom is its great dependence on imported feeds and other inputs.

Rabbits

Rabbit production is a backyard operation. Rabbits are reared in cages made out of cheap, locally available materials. Most of the rabbits produced are used for home consumption or sold to other farmers to start a rabbit operation.

Fig. 1 is a schematic of the structure of animal industry in Caricom and emphasises the weak links in marketing, processing and packaging of animal products.

Trade and Imports of Animal Products

Belize and Guyana are the only countries in Caricom that are self-sufficient in beef and have the potential for both regional and extra-regional trade in this commodity. This export potential has been realized by Belize. However Belize has so far not been allowed by national animal health authorities to export Belize beef to regional destinations. Belize has however been able to export beef to the U.S. and to the French Caribbean Islands.

Regional trade in animal products is virtually non-existent. The cases of Belize and Guyana have been referred to above and excepting for sporadic exports of pork from Barbados and Jamaica to Trinidad and shipments of live animals (mainly sheep and goats) from Grenada and St. Vincent to Trinidad and Tobago, regional trade in animal products, while potentially viable, has so far not been undertaken.

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This situation continues to obtain in spite of relatively large demands (Table 2) and projected demands for animal products (Table 3). Regionally what has obtained so far is that regional needs for animal products continue to be met by imports from North America, Europe and Oceania. These traditional sources of animal products have in certain ways militated against the development of regional potential in the production of animal products. This is particularly so with respect to milk and milk products. The experience in the Region is one where in spite of institutional mechanisms for promoting local milk production (e.g. dairy settlement schemes production has stagnated or decreased because of milk pricing policies and/or milk processing interests and arrangements.)

Most processors prefer to purchase milk powder relatively cheaply from the intervention stocks held in Europe and North America than encourage the local production of milk. The Food and Agriculture Organisation (FAO) has estimated that world milk production in 1982 grew by one percent to about 478 million tons of which 430 million tons were cow milk. At the same time butter and skim milk powder intervention stocks in the EEC and the U.S. were mounting (Table 4). These intervention stocks are unloaded on the world market at such relatively low prices that developing country processors prefer them to locally produced milk. The only snag to all these (and considering the need for food security) is that both the U.S. and the EEC have now deliberately set in motion policies aimed at reducing or whipping out these intervention stocks. They are doing this because their economies can no longer subsidize these products on the world market. Ironically one of the strategies is to give incentives to dairy farmers to reduce milk production.

The Future for Regional Animal Production

The Regional Livestock Complex was conceived as an effort to reduce the regional dependence on imported animal products at high foreign exchange costs In spite of enormous efforts by both the Caricom Secretariat and Regional Institutions very little impact has been made on the regional import bill for animal products. Arising out of that effort, however, have been a number of animal production projects. These include the Dairy Project in St. Lucia, Diamond Dairies in St. Vincent, and the Montpellier Dairies in Jamaica, etc.). Recently the Caribbean Food Corporation initiated a beef project in Antigua

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and a hatching eggs project in Barbados. The Trinidad Government has recently started a broiler breeder project. The Bleaheim sheep project and the Milk Production Systems Project (CARDI/IDRC) in Guyana are all products of the efforts of the Regional Livestock Complex. It is anticipated that a Regional Sheep and Goats project will soon be funded. This will have a focus in Jamaica where the Font Hill Sheep and Goat project has failed to materialise.

These projects emphasise the need for long term planning and the need for sustained efforts to ensure regional food security in animal products. In this a combination of technical and institutional policy arrangements are indicated.

The constraints to regional self-sufficiency in animal products (Table 5) are still there; however these should not belie the need for and the potential of the region to drive for increased animal productivity. With regard to livestock the role of forages in both meat and milk production and in land management cannot be over emphasised. What is needed is a sustained effort on the part of all planners.

This paper has had to be prepared at a very short notice. Therefore any errors of omission are particularly regretted.

Table 1. Comparision of Per Capital Milk and Beef Production in Selected Countries

Country	Human Population ('000)	Cattle Population ('000)	Production per capitia Milk kg	Beef kg
CARICOM	5,321	807	20	4.6
Puerto Rico	3,811	489	119	5.3
Israel	3,951	265	187	3.5
Norway	4,100	988	478	18.5

Source: CARICOM Herd Improvement Record Keeping System (HIRKS). A report prepared for CIDA by T. Body, G. Craven, Robin Flockton, J. Moxley, H. Patterson, G. Proverbs and P. Osuji. Sept. 1984, p. 16.

Table 2. CARICOM 1980 - Demand for Animal Products

(metric tons)

Countries	Beef	Mutton	Pork	Poultry	Table Eggs	Milk
Antigua	542	222	443	862	349	8261
Barbados	4322	1271	3305	7881	1786	12459
Belize	1339	548	1096	2130	635	11270
CARICOM	51054	10202	27526	83793	34613	195524
Dominica	527	216	431	839	275	7598
Grenada	855	350	700	1360	866	10183
Guyana	8804	102	2457	7371	4476	59739
Jamaica	20594	4290	11155	34323	16072	52351
Montserrat	108	44	89	173	50	1602
St. Kitts-Nevis	670	274	548	1066	309	3719
St. Lucia	1411	577	1155	2245	686	7507
St. Vincent	647	265	529	1029	516	2353
Trinidad & Tobago	11235	2043	5618	24514	8603	24390

Source: Personal Communication - CARICOM Food and Nutrition Strategy Study Group. May, 1985.

Table 3. CARICOM Projected Demand (1990) for Animal Products

(metric tons)

Countries	Beef	Mutton	Pork	Poultry	Table Eggs	Milk
Antigua	2043	630	1683	2103	1256	23048
Barbados	12361	2923	9915	16944	5537	28225
Belize	6613	182	5156	10797	988	16003
CARICOM	89149	18449	51512	141962	55246	273305
Dominica	311	158	241	646	146	1921
Grenada	727	315	581	1251	719	9267
Guyana	8892	111	2432	8182	4386	65170
Jamaica	6730	5834	2900	22906	3375	31934
Montserrat	136	52	114	291	65	710
St. Kitts-Nevis	938	362	778	1386	442	4905
St. Lucia	2370	877	1998	3300	1207	11182
St. Vincent	1178	427	995	1595	991	3740
Trinidad & Tobago	46850	6578	24719	72561	36133	77197

Source: Personal Communication - CARICOM Food and Nutrition Strategy Study Group. May, 1985.

Table 4. Butter and Skim Milk Powder Intervention Stocks in the EEC and the U.S. (000 tons)

Year	Butter		Skim-milk Powder	
	EEC	US	EEC	US
1980	376	123	244	249
1981	276	98	360	370
1982	389	180	583	540

Source: Asian Livestock Vol. III, No. 12, Dec. 1982.

Table 5. Constraints to Animal Production

The main constraints to animal production in CARICOM are:

1. Poor nutrition due to the seasonal unavailability of local feed, poor quality pastures and high cost of buying feed.

2. Parasitism in animals. Both ecto and endo parasites are a problem. Lack of information among farmers, lack of an adequate supply and high cost of antiparasite drugs have limited the productivity of most animal species.

3. Marketing. The structure of the market, lack of adequate transportation, big differentials between farm gate prices and the retail prices, and absence of market information to farmers are the areas needing attention. Animals are sold by sight and pricing policy is consumer oriented.

4. Distance to processing facilities. The available processing facilitie may increase the farmer's earnings through the value added to their processed products.

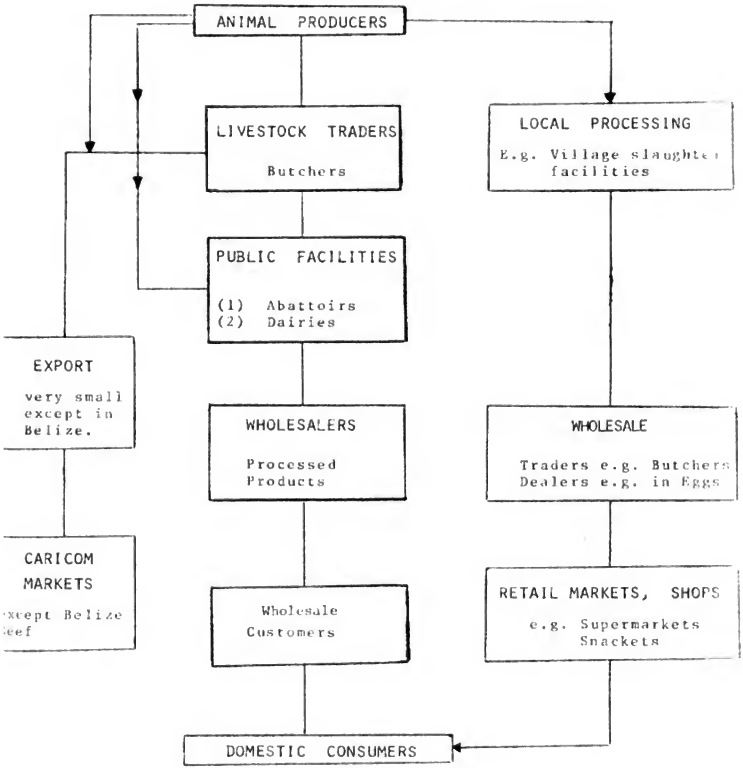
5. Unavailability of suitable land for pasture expansion. Most farmers are willing to expand only if they could get access to more suitable land.

6. Unavailability of suitable breeding stock especially among ruminants.

7. Praedial larency and predation by dogs, especially small ruminant production.

8. Poor management expertise on the part of the farmers. Housing nutrition, and health seem to be the main areas of concern.

FIG. 1. STRUCTURE OF THE LIVESTOCK INDUSTRY



ANNEX III

RECOMMENDATIONS OF THE FIRST MEETING OF CHIEF VETERINARY OFFICERS - CARICOM
KINGSTON, JAMAICA - MAY 24-25, 1985.

Resolution regarding Amblyomma variegatum, Heartwater, Dermatophilosis in the Caribbean

CONSIDERING:

(i) The confirmation of Heartwater in the islands of Antigua, Guadeloupe and Marie Galante associated with deaths of ruminant livestock;

- The spread of the vector, Amblyomma variegatum throughout the islands of the Eastern Caribbean except for the British Virgin Islands, Barbuda, Grenada, St. Vincent and the Grenadines, and Trinidad and Tobago;

- The associated increase in incidence of dermatophilosis (cutaneous streptothricosis) with losses that deter the raising of ruminant livestock;

(ii) The concern of remaining countries in the hemisphere due to the alarming speed with which Amblyomma variegatum has recently spread among the islands which spread can be expected to continue and the presence of other vectors of Heartwater in those countries;

(iii) The support expressed at international meetings and recommendations proposed for control and eradication measures with technical expertise already shared and developing in the Region;

(iv) That it is considered technically possible to eradicate Amblyomma variegatum because of its relatively low population growth rate:

- Adults are found on larger animals, the major hosts which are treatable with available effective insecticides;
- Of the absence of large numbers of wild life, small mammals and ground nesting birds that would contribute to wider dispersion;
- Of the success of eradication projects in St. Croix and Puerto Rico;

(v) That control measures are being adopted in some islands with beneficial results and resources may be available through interested agencies to promote preliminary information and appraisal studies and the implementation of pilot-projects to test the feasibility of eradication;

(vi) That suppliers of insecticides are willing to contribute to these measures;

RECOMMENDS:

That the Governments of Member States through CARICOM urgently seek the active support and collaboration of the Governments of France, Holland, the United Kingdom, the United States of America and other interested countries of the Hemisphere.

That countries adopt or take steps to improve their control measures including better public information to promote commitment and owner participation and control of livestock movement within infested areas.

That countries with whatever assistance possible undertake a pilot project to quantify economic benefit and test feasibility of eradication procedures.

That countries develop a regional approach to eradication and seek the necessary funds to implement same.

That countries support training, research and other measures to provide the infrastructure necessary for successful completion of such projects.

That countries, where Amblyomma variegatum does not exist, make its occurrence a notifiable condition, strengthen surveillance procedures and adopt response capability measures in order to eliminate it swiftly should it be introduced.

That CARICOM, Commonwealth Veterinary Association and IICA collaborate in the execution of this Recommendation.

SUMMARY OF CONCLUSIONS OF THE SPECIAL MEETING
OF CARICOM MINISTERS RESPONSIBLE FOR AGRICULTURE-
GEORGETOWN, GUYANA - OCTOBER 7-8, 1985.

Control and Eradication of Amblyomma Variegatum,
Heartwater and Dermatophilosis

THE MEETING:

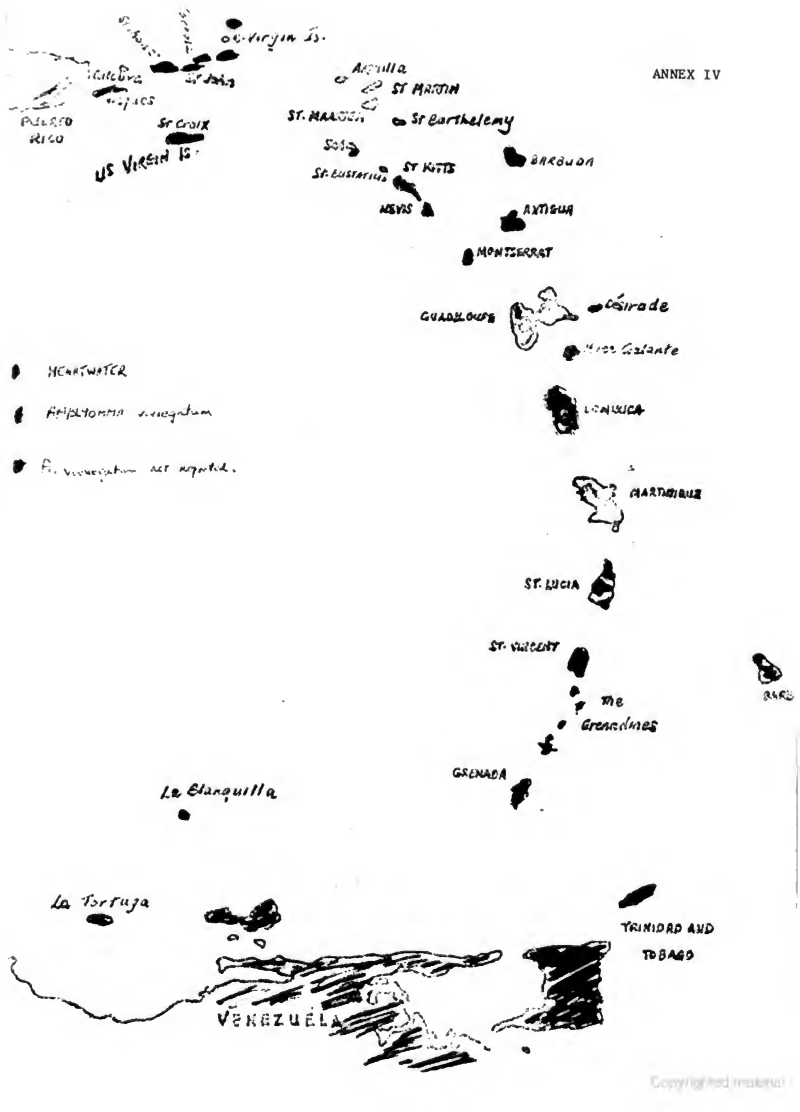
Conscious of the alarming speed with which Amblyomma variegatum has spread through the Region and the presence of other vectors of Heartwater;

Reiterated their commitment to the control and eradication of Amblyomma variegatum;

Expressed support for the efforts of IICA to collaborate with relevant US agricultural agencies towards obtaining funds for the conduct of a feasibility study on the eradication of Amblyomma variegatum and Heartwater in the Region;

Requested the Secretariat to transmit its views to IICA.

ANNEX IV



FECHA DE DEVOLUCION